EDITORIAL RESEARCH REPORTS

1959
Vol. II

WATER NEEDS AND RESOURCES

by

Helen B. Shaffer

	Page
PROSPECTIVE NATIONAL WATER SHORTAGE	737
Economic Nature of the Shortage Problem	737
Demand for Federal Water Resources Policy	739
Pressures For and Against Federal Action	740
EXISTING SUPPLIES AND FUTURE DEMAND	741
Growing Drain on Present Supplies of Water	742
Methods of Stretching the Existing Supplies	743
Danger of Depleting Underground Resources	744
Main Water Problem Areas in United States	746
EXPERIMENTS IN DESALTING SEA WATER	747
Existing Salt Water Conversion Operations	748
Federal Support of Saline Water Research	749
Processes for Separating Salt From Water	750
Vital Question of Cutting Conversion Costs	751
Cost of Delivering Desalted Water to Users	753

No. 13
Oct. 2

THE right to reproduce material contained in *Editorial Research Reports* is strictly reserved to the newspaper clients of the service. Verbatim use of such material by others will be permitted only upon written authorization of the editor.

RICHARD M. BOECKEL, *Editor*

Editorial Research Reports
1156 Nineteenth Street, N.W.
Washington

WATER NEEDS AND RESOURCES

A WATER SUPPLY problem, growing steadily more serious as the country's population and activities expand, has engaged the attention during the past dozen years of four presidential commissions, a committee of cabinet members, and a number of committees of Congress. Now, a special Senate Committee on National Water Resources is about to open two months of hearings in 17 states.[1] The committee was created last spring to make a new and exhaustive inquiry into national water requirements and resources as a basis for legislation looking to avoidance of critical shortages in the future. Concern over water supply has led also to increases in federal appropriations for projects to develop a feasible method of taking the salt out of water from the sea or other sources of saline or brackish water.

Economic Nature of the Shortage Problem

How serious is the water supply problem? Certain localities in arid sections of the country are chronically short of water, and cities in humid areas occasionally are forced to curtail water use during dry spells to prevent depletion of reservoirs. During 1957, a year of drought which struck not only the arid West but also many areas of the East, more than 1,000 communities with one-seventh of the nation's population suffered some degree of water shortage requiring a temporary curtailment of use by local consumers.

Water shortages to date have been largely local or regional. But expert studies indicate that if existing supplies are not greatly expanded, local shortages may become so numerous within 15 or 20 years as to produce a supply crisis of national proportions. Such an eventuality would halt industrial growth in many areas and force millions of

[1] The hearings, opening at Bismarck, N. D., on Oct. 7, are scheduled to wind up Dec. 8 at Boston, Mass. The states the committee will visit, in addition to Massachusetts and North Dakota, are California, Florida, Idaho, Iowa, Kansas, Louisiana, Maine, Michigan, Montana, New Mexico, Pennsylvania, South Carolina, South Dakota, Utah, Wyoming.

individuals to forgo for indefinite periods their customary liberal use of water for personal purposes and household purposes.

There is plenty of moisture in the United States, and the nation has the technical capacity to increase the supply in places where more water is needed. The problem, largely economic, results from the fact that in most areas of high consumption the easily accessible and hence cheap sources of supply already are being so intensively utilized that it is necessary to go elsewhere for additional water.

When that time comes, several questions arise. Should conduits be extended to new but more distant sources? Should an effort be made to tap more underground sources? Should treatment facilities be expanded to enable more extensive re-use of water? Should more be done to capture rain water or streamflow which now courses to the sea? Should research on desalinization be intensified in hope that the abundant supply of sea water might be made economically available for fresh water uses in many areas of shortage?

Complications in Water Resource Development

Complicating the answers to these questions is the fact that water has multiple uses and that the development of a facility for one purpose may affect disadvantageously its use for another purpose. Drawing of water for consumption may reduce navigability of rivers. Overdrawing from underground sources already has lowered the water table in some areas or has caused an inflow of brackish water that cannot be used for ordinary purposes. Use of water as a waste carrier has caused widespread pollution of streams, killed off aquatic life, and made nearby land unusable or undesirable for residential, recreational or other purposes.

Water shortages raise the problem of equitable distribution of available supplies. Communities in which water sources are located often protest withdrawals for consumption in other areas. The controversy may be between two or more states or between different areas of a single state. In California, which is about to embark on a two-billion-dollar water development project, the legislature spent 10 years debating whether it was fair to draw water from the humid northern section of the state to supply the arid southern section.

Demand for Federal Water Resources Policy

The function of supplying water to a community has been viewed traditionally as a state and local responsibility. The federal government entered the sphere of water resources development on a piecemeal basis, first in connection with river and harbor development, later in connection with projects for flood control, for reclamation and conservation of farm land, for control of stream pollution, and for generation of electric power. The Hoover commission on government reorganization listed 25 different federal agencies which in 1955 had functions related to water and its use or control.

From time to time, advocates of a comprehensive national water resources policy have proposed coordination of all governmental activities concerned with water, and overall planning of facilities constructed to meet multiple needs. The Hoover commission recommended that Congress enunciate such a policy, keeping in mind that "Water resources should be developed to assure their optimum use and their maximum contribution to the national economic growth, strength and general welfare."

A Rockefeller Brothers Fund report last year observed that "Typically, water problems are regional problems and often can best be dealt with by specifically designed public agencies." The Port of New York Authority was cited as a type of regional authority well fitted to deal with water supply problems. "In addition to these regional bodies," the Fund report stated, "a degree of national policy formation and coordination, possibly centralized in one federal agency, is essential for such nation-wide problems as water pollution and for research into technological problems of water conservation."

The Senate voted on April 20 to set up the Select Committee on National Water Resources. Speaking for the authorizing resolution last Jan. 27, Sen. Mike Mansfield (D Mont.), one of its sponsors, told the Senate that none of the reports of recent Executive Branch commissions on water resources had become "the basis for congressional action"; in fact, the reports were "not actually addressed to congressional action." The time had come, Mansfield said, "for a broad-gauge legislative program as the basis for comprehensive water resources development by federal, state and private agencies." Legislation was needed to

"furnish the impetus for coordinated development at a rate that will provide the quantity and quality of water that will be required in the coming years . . . [and] encourage the adoption of new technical discoveries and improvements."

The committee, whose members have been drawn from four standing committees of the Senate with jurisdiction over some phase of the water problem,[2] is headed by Sen. Robert S. Kerr (D Okla.). The Senate resolution requires the group to direct its attention to:

> (1) The character and extent of water resource projects that will be needed to be in operation between the present time and 1980 in order to supply the water use requirements of population, agriculture, and industry, including . . . navigation development and hydroelectric power generation.
>
> (2) The character of legislation that may encourage the adoption of new technical methods and improved process[es] for increasing the usefulness of available water resources, including but not limited to weather modification, evaporation and evapo-transpiration reduction, desalination of saline and brackish waters, seepage control, waste-water salvage, and the application of nuclear energy.

Recommendations for legislation are to be submitted no later than Jan. 30, 1961.

Pressures For and Against Federal Action

Any legislation proposed by the committee implementing a federal water resources policy is likely to be highly controversial. While increasing demands are being made for federal assistance in meeting the water supply problem, pressure is mounting also to prevent federal control in a policy area traditionally belonging to the states.

The National Rivers and Harbors Congress on May 15 called for additional federal assistance in construction of local sewage plants and opposed proposals to require communities to pay a larger share of the cost of water resource projects within their boundaries. But the National Watershed Congress, a group of 25 agricultural, business, industrial and conservation organizations, on May 27 asked Congress to reassert the primary authority of state governments in allocation of water among competitive uses and users.

This question is of particular moment in the naturally

[2] Interior and Insular Affairs, Public Works, Interstate and Foreign Commerce, and Agriculture and Forestry committees.

arid areas of the West. Clarence A. Davis, a former Solicitor of the Department of the Interior, said in an address before the American Bar Association on Aug. 25, 1958:

> The decisions with reference to many of the questions of federal control of water will have a profound effect upon the future economic life of our country. . . . In at least half the geographical areas of our country the control of water means the direct control of land, for the land without the water is useless; it means the control of the location of industry, which in turn means the control of the location of population; it means the power to replace an existing economy with a new economy; to sound the death knell of settled areas and to raise up new areas—all by the manner in which we administer this water resource.

Two factors were said by Davis to be promoting extension of federal control over water supply. One was "the tremendous and nation-wide urge for the utilization of the federal function of flood control for the actual purpose of providing storage reservoirs to provide municipal water supplies." The Flood Control Act of 1958 provided for construction of storage facilities to meet potential municipal and industrial water needs. The second factor cited was the pressure on the federal government to take larger responsibility for abatement of stream pollution, a problem closely related to that of water supply. The Water Pollution Control Act of 1956 authorized federal expenditures of $500 million ($50 million annually) to meet up to 30 per cent (or $250,000, whichever is smaller) of the cost to a locality of building, improving or expanding waste treatment facilities. By June 30, 1959, a total of $131,558,249 had been granted for construction in more than 1,500 localities of facilities that will ultimately cost $685 million.

Existing Supplies and Future Demand

SECRETARY OF THE INTERIOR Fred A. Seaton recently predicted that within the next two decades "the availability of water—just plain, ordinary water . . . may be our Number One domestic problem."[3] Existing and impending shortages result directly from the swift rise in demand. The demand in some areas has grown beyond

[3] Speech, National Watershed Congress, Washington, D. C., May 25, 1959.

the capacity of the facilities which bring in water for municipal, industrial, and agricultural purposes. In some places, high demand has begun to deplete natural sources of supply in the area.

Population and industry always have tended to grow where water is abundant, but in recent years improvement of methods of obtaining water from distant sources has encouraged growth even in arid sections of the country. Irrigation on a vast scale in the dry lands of the West has made tremendous demands on water resources. Southern California, where 60 per cent of the state's people live, has only 2 per cent of the state's water resources but consumes three-fourths of the water available to California from inside and outside the state. Even in areas liberally supplied with water, concentrations of population and industry have taxed nature's abundance. In addition, measures taken in some places in "ignorance of the delicate balance involved in natural water supply" have increased supplies temporarily while permanently depleting natural resources.[4]

Growing Drain on Present Supplies of Water

Water consumption in the United States grew twice as fast as population in the first half of the present century—the population doubled, water consumption quadrupled. Various factors contributed to the increase in per capita use: Rising standards of living encouraged more liberal use of water by individual consumers; industrial expansion made heavy demands on water for cooling purposes; development of hydroelectric power increased utilization of streams; and extension of irrigation into arid sections of the country for agricultural purposes required more and more water.

The Geological Survey estimated in 1955 that 240 billion gallons of water a day were being withdrawn from American streams, reservoirs and wells for all uses. The total amounted to around 1,500 gallons a day for every man, woman and child in the country. The Commerce Department has estimated that publicly owned water companies alone supplied 20 billion gallons a day in 1958 to about 117 million persons in their service areas—a per capita daily average of about 170 gallons of tap water. In 1900, when people living in public water service areas numbered

[4] Edward A. Ackerman, lecture at U.S. Department of Agriculture Graduate School, Feb. 13, 1957.

only 30 million, the daily average supply was three billion gallons and the per capita average about 100 gallons.

Population is now increasing at a rate of three million a year. Interior Department hydrologists estimate that 20 years from now the total demand will be in the neighborhood of 500 billion to 600 billion gallons of water a day. The Commerce Department expects the population in areas served by public water utilities to increase to 149 million by 1975, and daily consumption in those areas to nearly 30 billion gallons.

Increasing demands of agriculture for irrigation water will magnify future supply problems. Only 7 per cent of the country's cultivated land is now irrigated, and 96 per cent of all water devoted to irrigation is utilized for that purpose in 17 western states. But a growing number of farmers in the East are beginning to recognize the possibilities of expanding production through irrigation. Irrigation imposes a much heavier drain on water resources in the West than any other water use.

The chief hydrologist of the Geological Survey told the Senate Interior Committee last March 24 that "As matters stand now, most water that is immediately available and inexpensive to use at each individual point is in use already." Therefore, additional supplies to meet the rising demand will have to be provided through conservation, development of now unutilized resources, and "improved coordination of the prospective uses."

In its report on the water study resolution, the Senate Interior Committee pointed out that water development programs have to be instituted long before the requirements for water materialize. "Even relatively small water projects take 10 to 15 years for planning and construction, and most projects that would provide substantial quantities of water would take a correspondingly longer time. This indicates that the projects and other measures needed to meet the 1980 requirements for water should be started in the very near future."

Methods of Stretching the Existing Supplies

There is no overall shortage of water resources in this country, nor is there likely to be one in the foreseeable future. The primary source of all water is precipitation, which replenishes moisture lost from soil and streams.

Precipitation varies considerably from area to area in the United States and from time to time in the same area, but over the years the amount of rainfall in the country as a whole remains fairly stable.

Precipitation averages about 30 inches a year, which equals 4,300 billion gallons a day. The equivalent of about 21 inches of the precipitation is returned to the atmosphere by evapo-transpiration.[5] Withdrawals for all purposes now take only three of the remaining nine inches; the rest sinks into the ground or flows to the sea.

Much of the unused rainfall is a potential source of water supply for domestic and industrial purposes. It has been estimated that 1,145 billion gallons of rain water a day—more than four times the total amount withdrawn for all purposes—flows unutilized into the oceans. A government report on potential water supplies states that "a minimum daily flow of about 630 billion gallons of usable quality" could be made available from this lost water; development of "storage and regulated-release" facilities and abatement of stream pollution would be necessary.[6]

The water supply situation could be improved, without tapping this potential source, if supplies now readily available were used more intensively. Use of water does not necessarily mean consumption in the sense of permanent withdrawal. Approximately three-fourths of all water taken for all purposes is returned to surface streams. Forty per cent of the water used for irrigation flows back into streams and can be used again. Ninety per cent of the water consumed by individuals and 98 per cent of that used in industrial operations—chiefly for cooling—is returned.[7] Water once used, however, is often so polluted that it cannot be re-used without treatment. Shortages may develop not only from lack of water but also from lack of water fit for use. Installation of pollution abatement facilities has barely kept pace with the increase of pollution.

Danger of Depleting Underground Resources

A potential source of abundant water supply lies below the surface of the earth. The full extent of this supply is not known, but it has been estimated that the country's

[5] Evaporation from the ground and bodies of water and transpiration from plants.

[6] Department of Commerce, *Water Resources Developments* (June 1959), p. 7.

[7] Geological Survey estimates indicate that irrigation accounts for 46 per cent of total water consumption, industry for 46 per cent, and personal and household uses for 8 per cent. Agriculture is the heaviest user in the West, industry in the East.

aquifers—underground water-bearing geological formations—hold more water than all the lakes and surface reservoirs combined.[8]

One-fourth of all the water used today comes from wells, chiefly on farms and in small towns. Like surface lakes and streams, underground reservoirs are ultimately dependent on rainfall for replenishment. Where rainfall is scanty and extensive pumping of underground water has taken place, depletion of the underground resources can be expected. This is the case in the Central and San Joaquin valleys in California, in south central Arizona, on the high plains of northwestern Texas, and in parts of Arkansas and New Mexico.

> The total overdraft in the Southwest has been estimated to be approximately five billion gallons per day. If these areas of overdraft continue their current rates of underground water use, their economic development most assuredly will be adversely affected at some future time. Remedial measures to help balance draft against recharge have been taken in some areas. . . . Nevertheless these measures are expensive and of limited efficacy.[9]

An authority has stated that losses from overpumping may be permanent, because the underground reservoir is "emptied of water that may have taken decades or centuries to accumulate." Many consumers do not know that they are "using more than the perennial supply and that the supply will be exhausted unless action is taken." [10] Pumping from closely spaced wells has caused declines of the water level in parts of nearly every state. Pumping from wells near rivers has depleted the streamflow or, in other instances, has diverted the streamflow to cause a dangerous rise in water levels under cities. Unwise irrigation and drainage projects have adversely affected storage of underground water resources and caused either depletion of such resources or an overflow which renders the land useless.

When underground water in some areas is overpumped, saline or other mineralized water flows into the below-

---

[8] Harold E. Thomas, "Underground Sources of Our Water," U.S. Department of Agriculture Yearbook, *Water* (1955), p. 62.

[9] "Water Availability—a National Problem?" Federal Reserve Bank of Kansas City *Monthly Review*, December 1958.

[10] Corrective measures applied in some areas include "prevention of waste, a pro rata reduction of pumping from all wells, prohibition of further development, reclaiming of used water, artificial ground-water replenishment by surplus stream water, and importation of water from other areas."—Harold E. Thomas, "Underground Sources of Our Water," Department of Agriculture Yearbook, *Water* (1955), p. 62.

surface reservoir. The Geological Survey has found seawater encroachment in many heavily pumped areas along the Atlantic coast. Wells near the Delaware and New Jersey coasts are said to be yielding saline water, and saline water has moved into aquifers tapped by wells for municipal water systems in Florida. Even in inland areas, underground water may become saline through absorption from salt-bearing rocks.

Main Water Problem Areas in United States

Uneven distribution of water supplies has made for deficiencies in many parts of the country. The Geological Survey in a report submitted to a House subcommittee[11] on April 16, 1958, cited the following areas among those having serious water supply problems:

Delaware and Hudson River basins: "This region is humid and well-watered, but water demands are very large, and dependable local supplies of water for new municipal supplies and industry are becoming increasingly expensive to obtain or develop."

Savannah, Ga.: "Heavy pumping of ground water for municipalities and industry has developed a cone of depression that extends outward more than 20 miles. Near the center of the cone ground-water levels have declined as much as 100 feet."

Great Plains area: "In the semi-arid section of the Missouri River Basin many rivers and streams are saline at low flows. . . . The water is used . . . rarely for irrigation [and] is unsuitable for domestic supplies. Fresh groundwater supplies are generally deficient except in areas underlain by geologically young deposits of sand and gravel."

Kansas: "Saline surface waters are one of the major problems."

Arkansas-White-Red River Basin: "Wide seasonal and yearly variations in the surface-water supply. . . . Cities in the headwaters of the basins . . . have serious water shortages during droughts. . . . Principal cities in western Oklahoma and parts of Kansas are perennially short of municipal and industrial water because the natural supply is small and either naturally saline or polluted by industrial wastes."

[11] Public Works and Resources Subcommittee of House Government Operations Committee.

Western Gulf area: "The balance between supply and demand is favorable in the more humid eastern part of the area but demand is approaching dependable supply in the western part. The two principal farming areas, the Rio Grande Valley and the Pecos River Valley, definitely are short of water for irrigation. Many parts of Texas are deficient of irrigation water and in the northwestern part (High Plains) of the state pumping from wells is depleting the supply much faster than it is being replenished."

Colorado River and Great Basin: "According to present estimates, demand . . . will equal supply in about 25 years and poor quality of water may be a limiting factor in some localities. Although the current supply and demand are not far out of balance, much more water could be used for irrigation if it were available. In nearly all of Arizona, municipal and industrial water is in short supply during droughts. Water in the southern third of the state is inadequate to meet all irrigation needs."

California coastal area: "Balance between supply and demand is favorable if the area as a whole is considered, there being a surplus in the northern part and a shortage in the southern part."

Experiments in Desalting Sea Water

THE NEED to spend vast sums to pipe fresh water from distant places to centers of population and industry has intensified interest in the possibility of getting potable water from the abundant saline sources. Techniques for separating salt from water by heating or by freezing the brine have been known and used for centuries. But no feasible method has yet been developed to make desalted water available for large-scale distribution at a cost acceptable to the ordinary consumer.

John C. Geyer, chairman of the Sanitary Engineering Department of Johns Hopkins University, told a House subcommittee[12] on April 17, 1958, that cost studies indicated that it would be cheaper for California to reach across

[12] Public Works and Resources Subcommittee of House Government Operations Committee.

the continent to the Susequehanna River for fresh water than it would be to draw and desalt water from the Pacific Ocean. California already has spent $220 million on conduits that carry water hundreds of miles from the Colorado River on the Nevada-Arizona border to Los Angeles, and even lengthier and more costly intrastate distribution facilities are now being planned.

Existing Salt Water Conversion Operations

Conversion of salt water into fresh water is economically practical today in a number of special cases. Large distillation plants have been established for industrial purposes at Los Angeles and Morro Bay, Calif., and at Marcus Hook, Pa., and Congress last year authorized construction of a conversion plant in the Virgin Islands. Distillation facilities at Kuwait on the Persian Gulf and at Aruba, Curacao and Nassau in the West Indies have a daily capacity of from one million to 3.5 million gallons. Smaller conversion plants are operating in Argentina, Bermuda, Ecuador, Gibraltar, Greenland, Italy and Saudi Arabia.[13] An estimated total of more than 15 million gallons of fresh water is now obtained from saline sources every day.

Interest in perfecting conversion processes, and particularly in bringing down costs, is global. A technical symposium on the subject, sponsored by the National Academy of Sciences, National Research Council and the Department of the Interior, reported in November 1957 on activities in nine countries—Australia, France, Germany, Great Britain, Israel, Italy, Japan, Netherlands, and South Africa. Another symposium was held last year in Turkey.

The U.S.S.R. has been active in research on conversion of saline water and is believed to have made advances paralleling those of the United States. Soviet success in this field not only would permit greater exploitation of arid regions in central Asia and along the coast of the Caspian Sea; it would also enable the U.S.S.R. to seek favor among arid countries of the Middle East by offering them the results of its research. The Organization for European Economic Cooperation created a special group in 1952 to coordinate research on saline and brackish water conversion. Although the group was disbanded in 1956, independent research has continued in Belgium, Denmark, France, Germany, Great Britain, Netherlands, and Sweden.

[13] The Union of South Africa demineralizes brackish water found in mines.

Small-scale desalinization of water by evaporation has been practiced on shipboard for centuries. In a report to Congress on Nov. 21, 1791, Thomas Jefferson, then Secretary of State, summarized the history of saline water conversion from the 16th century until his day. The Department of Defense is currently doing research in this field in an effort to bring down costs of the conversion carried out on naval vessels and for other military purposes.[14]

FEDERAL SUPPORT OF SALINE WATER RESEARCH

Little concerted effort to solve the cost problem was made in this country until prospects of a nation-wide water shortage loomed after World War II. The Saline Water Act of 1952 recognized "the acute shortage of water in the arid areas of the nation and elsewhere." It directed the Secretary of the Interior to undertake a five-year program in search of a "practicable low-cost means of producing from sea water, or from other saline waters, water of a quality suitable for agriculture, industrial, municipal, and other beneficial consumptive uses." The act authorized the Secretary to make research grants and to contract with private agencies for development work "to ascertain the lowest investment and operating costs and to determine the best plant designs and conditions of operation."

An amendment in 1955 extended the research and development program to June 30, 1963, and allowed an additional two years for completion of research and a third year for correlation and coordination of the results of the studies. The amendment increased total authorization for the program from the original $2 million to $10 million and authorized expenditure of $2.5 million to set up federal laboratories. Actual appropriations to date have totaled $5.9 million.

After reviewing the work of the Interior Department's Office of Saline Water, the House Government Operations Committee observed in August 1958 that "a good deal of progress" had been attained but that the department had "not regarded the program with the sense of urgency which Congress intended it should have." The committee found that no desalting process in use or under development offered "promise of overcoming the difficult problems stand-

[14] John R. Townsend, special assistant to the Assistant Secretary of Defense for Research and Engineering, told the House Government Operations subcommittee April 16, 1958, that the department's requirements for desalted water were being met, but that "The cost is high, equipment maintenance is high, . . . equipment weight is excessive, and manpower requirements are too large."

ing in the way of producing fresh water from sea water in large quantities and at costs economically competitive with other sources in most areas." It recommended that the agency step up its program of research and undertake large-scale testing of the most promising methods.

An act approved Sept. 2, 1958, authorized expenditure of $10 million to construct large-scale demonstration plants for production of fresh water from saline or brackish water.[15] The plants were to be designed to demonstrate the "reliability, engineering, operating and economic potentials of the sea or brackish water conversion processes which the Secretary [of Interior] shall select from among the most promising of the presently known processes." The act required building of at least five plants, one in each of the following general locations: the Atlantic, Pacific and Gulf coasts, the Northern Great Plains and an arid section of the Southwest. Freeport, Texas, on the Gulf of Mexico, is the only site so far selected.

Processes for Separating Salt From Water

A number of processes for separation of salt from water have been devised. Those most generally employed in the case of sea water involve some form of distillation or evaporation; electrical and chemical processes have been found more suitable for removal of salts from brackish water. A recently developed method which has attracted much attention is electrodialysis, in which electrical current is used to drive the water through a series of membranes that screen out the salts. Other methods utilize the natural process of osmosis across membranes separating solutions of different degrees of salinity.

A selection board created by the Office of Saline Water has had 17 different processes under review in trying to find the ones most suitable for the large-scale demonstration projects authorized last year. To date the board has selected three processes:

1. *Long-tube vertical multiple-effect distillation:* Development of this process, to be demonstrated at Freeport, was started early in 1955 by a private company under contract with the Office of Saline Water. The long-tube vertical evaporator is well known in the salt and chemical industry. Its use in salt water conversion was considered promising because early tests indicated that it

[15] Brackish water is less salty than sea water, which contains at least 35,000 parts of dissolved salts per million parts of water. Any water with less than 1,000 parts of salts to a million parts of water is considered fresh water.

might provide a means of controlling the formation of scale on equipment—long a problem where salt water is brought to high temperatures.

2. *Multi-stage flash distillation:* A process by which sea water is passed through a series of chambers in which it is "flashed"; that is, suddenly brought to boil, the condensed vapor providing the end-product. The Atomic Energy Commission has been asked to make available a low-temperature atomic reactor to serve as the heat source. The site of this plant will be in California.

3. *Electrodialysis:* A process for conversion of brackish water, to be established at one of the inland locations.

In the meantime, research is continuing on other methods of saline water conversion. Various types of freezing processes are under investigation by private developers under contract with the Office of Saline Water. Some of the current research is devoted to acquiring basic data which may introduce an entirely new approach to the conversion problem. One project, for example, is a study of marine life which may have some influence on the salinity of brine. More than 100 different species of algae have been studied in laboratory cultures in an effort to identify those with a special faculty for accumulating sodium.

A number of scientists have testified to their belief that a larger part of the government investment should be directed to such basic studies, and that this type of research should be placed on a continuing basis in order to encourage scientists to go into this field of study. In the year ended June 30, 1958, only $25,000, or 3 per cent of the budget of the Office of Saline Water, was devoted to basic research. Some scientists feel that all-important research breakthroughs—discoveries that can lead to unforeseen practical applications—have not yet been made. The House Committee on Government Operations said in a report on the saline water program, Aug. 12, 1958, that "A sizable and steady basic research effort should be maintained now, so that additional fundamental knowledge will be on hand at such time as a crash program might become necessary."

Vital Question of Cutting Conversion Costs

The all-important question in salt water conversion is cost. Experts differ on how close current developments have come to surmounting the cost barrier. The average person in the United States now pays from 20c to 30c per 1,000 gallons for water. When the saline water program was initiated by the federal government in 1952, it was

estimated that conversion processes then in use could not produce potable water for less than $3 to $5 per 1,000 gallons. Some water authorities say $1 or less per 1,000 gallons is possible today. But other experts insist that the price tag actually would be considerably higher.

Costs would vary from place to place in accordance with such factors as the salinity of the water to be converted, amount of pumping required from source to conversion plant, and charges for the energy required to carry out the conversion process. Some of the lower cost estimates for desalinized water do not include the distribution costs that make up a part of the 20c-30c average charge for fresh water at the tap.

The House Government Operations subcommittee found "vague and unconfirmed" the cost estimates made by specialists and promoters of various processes. The committee concluded in a report on Aug. 12, 1958, that "save in a few exceptional localities, converting saline water would cost more than obtaining alternative fresh water from new distant sources." One of the major purposes of establishing the demonstration plants is to provide a practical determination of costs when the processes are put into operation on a large scale.

The price for converted salt water that will be acceptable in a community depends on what it has been paying for fresh water. Conversion of brackish well water to sell for $1.45 per 1,000 gallons proved economical in Coalinga, Calif., where fresh water used to be hauled in by tank car at a cost to the consumer of $7 per 1,000 gallons. Saline water conversion may hold similar benefits for the Virgin Islands, where fresh water brought by barge from Puerto Rico costs $5 per 1,000 gallons. But California decided that, to supply areas of major consumption, no demineralization process in its present stage of development could compete with distribution from natural sources in the state, even when it meant tunneling through mountains to bring fresh water hundreds of miles. A California official testified, however, that the state had five years—"ample time"—to carry out the necessary studies before making a final decision on whether to use demineralizing processes in its water development program.[16]

[16] Testimony of William Berry, chief engineer, Division of Resources Planning, California Department of Water Resources, before House Government Operations subcommittee, April 17, 1958.

Announcing selection of a multiple-effect distillation process for one of the demonstration plants, Secretary of the Interior Seaton said on March 2 that "We have reason to hope this demonstration plant will produce fresh water from the sea for less than $1 per 1,000 gallons." That figure would represent "a reduction of about 50 per cent under the cost of converting sea water in the most efficient commercial conversion plant in operation in the world today." Later, in a speech before the National Watershed Congress in Washington on May 25, Seaton said if the plant were enlarged to a capacity of 15 million to 20 million gallons a day, "We can expect the price per gallon to come down perhaps to . . . less than 60 cents."

Cost of Delivering Desalted Water to Users

Whether or not saline water conversion affords an immediate answer to the water supply problem, it is becoming apparent that rates now charged consumers for fresh water are likely to go up. Many communities are dependent on water distribution facilities that were built many years ago and will soon have to be replaced. Inflation caused a fivefold rise between 1932 and 1957 in the cost of constructing such facilities.[17] In many places, moreover, the most economical sources of water supply have already been tapped to the utmost.

Construction of water development facilities is a costly undertaking. The Department of Commerce has estimated that all private and public water resource developments in continental United States today represent a value of $179 billion at 1958 replacement costs, or about $1,025 per capita. To meet growing requirements, it has been estimated, a minimum of $171 billion more must be invested by 1975 in extension of existing facilities. Public water utilities alone were said to require an investment of $13.5 billion beyond the $30 billion invested in such facilities in 1958.[18]

Whether extensive resort to saline water conversion processes would bring down future costs cannot now be foreseen. A major cost bottleneck in the development of saline water facilities is the high energy requirements of processes now under consideration. Sea water conversion presents a

[17] Testimony of Luna B. Leopold, chief hydraulic engineer of the U.S. Geological Survey, based on estimates by *Engineering News-Record*, House Government Operations subcommittee, April 16, 1958.

[18] U.S. Department of Commerce, *Water Resources Developments* (June 1959), pp. 5-6.

particularly tough problem, because all water at sea level must be pumped for use. Surface reservoirs of fresh water, on the other hand, are usually at levels higher than the territory served, permitting gravity to carry the flow to consumers.

Any conversion process that might require only small amounts of energy, such as one utilizing the salt-absorbing properties of marine life, would bring down costs considerably. Some hope has been attached to use of sunlight as the source of power, but this method, which is technically feasible, entails a volume of capital investment that would cancel the cost advantage. Conversion costs are swelled by severe scaling and corrosion of the equipment used in desalinization. To cope with this problem, efforts are being made to develop methods which do not require high temperatures or which would incorporate a scale and corrosion control process.

It is hoped that the new knowledge to be acquired from operation of the demonstration plants will make it possible to get consumer prices of desalinized water down to a point at which they will compare favorably with charges for fresh water. With the cost of bringing in new supplies of fresh water rising, Seaton has foreseen the day when "these cost curves will . . . cross, and then converted sea water will be the less expensive of the two [and] in some localities it will be the only reliable source."